# Expanding the Goddard CSH Algorithm for GPM: New Extratropical Retrievals

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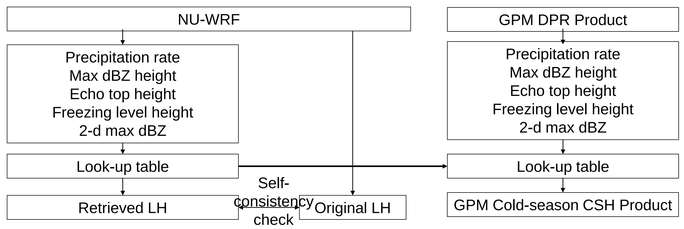
## Objectives

TRMM and GPM measurements have been providing an accurate 4D account of rainfall over the global tropics and mid-latitudes: information that can be used to estimate the space-time structure of latent heating (LH). The Goddard Convective-Stratiform Heating (CSH) algorithm has been used to retrieve LH associated with clouds and cloud systems in support of the TRMM and GPM missions. The CSH algorithm requires the use of a cloud-resolving model (CRM) to simulate LH profiles to build look-up tables (LUTs). However, the current LUTs in the CSH algorithm are not suitable for retrieving LH profiles at high latitudes or winter conditions that are needed for GPM. The NASA Unified-Weather Research and Forecasting (NU-WRF) model is used to simulate three eastern continental US (CONUS) synoptic winter and three western coastal/offshore events. Simulations of precipitation systems occurring at higher latitudes and in the winter season are needed for GPM. The main objective of poster is to describe the development and performance of a new Goddard LH algorithm for high-latitudes and winter conditions.

CSH is now using two different sets of LUTs with differing metrics, one for the Tropics and warm season (Lang and Tao 2018) and one for the cold season / high latitude / winter events.

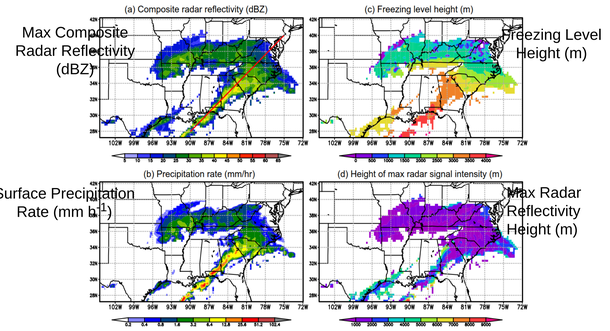
| Cases | Location | Simulation start time | End time |
|---|---|---|---|
| Maritime winter storms (CalWater2015) | Eastern Pacific (off the coast of California) | 00UTC02/05/2015 | 00UTC02/07/2015 |
| | | 00UTC02/18/2015 | 00UTC02/20/2015 |
| | | 00UTC03/15/2015 | 00UTC03/17/2015 |
| Continental synoptic winter storms | Eastern CONUS | 06UTC03/16/2014 | 06UTC03/17/2014 |
| | | 00UTC02/16/2015 | 12UTC02/17/2015 |
| | | 00UTC02/21/2015 | 12UTC02/22/2015 |

Schematic diagram showing the production of the new cold LUT from NU-WRF simulations and a self-consistency check

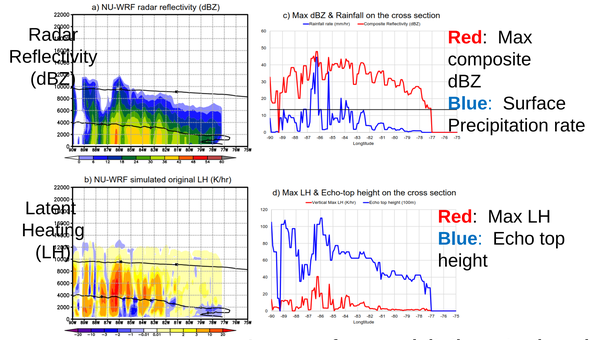



| Variables | Bin ranges |
|---|---|
| Surface rainfall rate (mm h$^{-1}$) | 0., 0.178, 1., 1.78, 3.16, 5.62, 7.5, 10., 13.3, 17.8, 22.4, 27.0, 31.6, 44.0, 56.2, 70.0, 100., 9999. |
| Max dBZ height (m) | 0., 500., 1000., 1500., 2000., 3000., 4000., 5000., 99999. |
| Freezing level height (m) | Negative, 0., 500., 1000., 1500., 2000., 2500., 3000., 3500., 4000., 4500., 5000., 99999. |
| Echo top height (m) | 0., 1000., 2000., 3000., 4000., 5000., 6000.,7000., 8000., 9000., 10000., 99999. |
| Max dBZ intensity | 10, 12, 14, …76, 78, 80 (from 10 to 80 with an interval of 2) |
| Vertical levels (80) | 0, 250,….21750, 22000 (0 to 22000 with an interval of 250) |

## 1. A winter storm over eastern CONUS

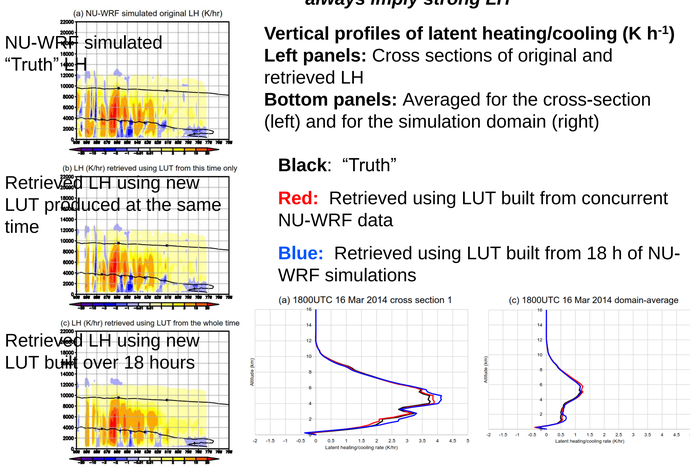



***Max composite dBZs are linked to higher precipitation rates while lower freezing level heights are linked with lower Max dBZ heights.***




***A close relationship between dBZ and heating occurs beneath the freezing level***

***Large surface precipitation rates have high composite dBZs. Strong LH occurs with high echo tops, but high echo tops do not always imply strong LH***



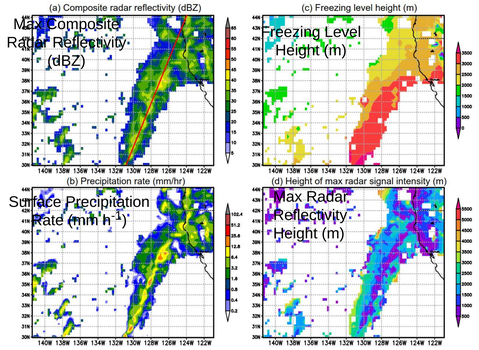

**Vertical profiles of latent heating/cooling (K h$^{-1}$)**
**Left panels:** Cross sections of original and retrieved LH
**Bottom panels:** Averaged for the cross-section (left) and for the simulation domain (right)

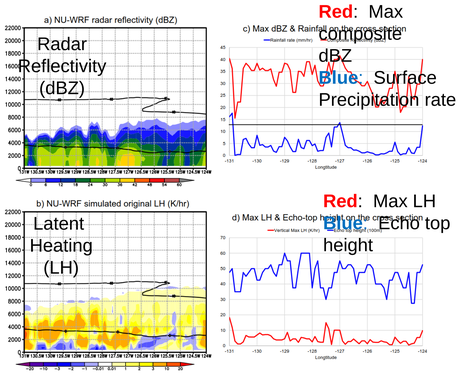
**Black**: "Truth"

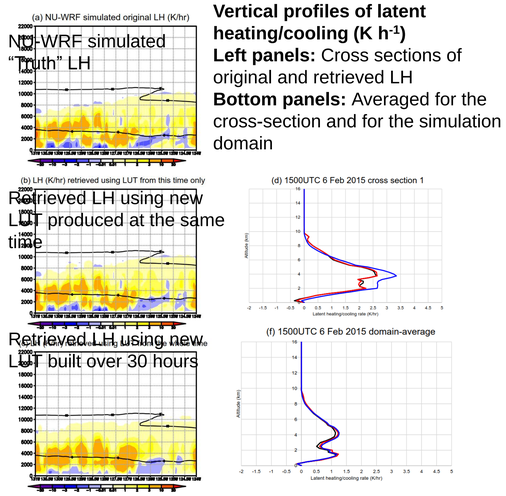
**Red:** Retrieved using LUT built from concurrent NU-WRF data

**Blue:** Retrieved using LUT built from 18 h of NU-WRF simulations

## 2. Eastern-Pacific maritime system

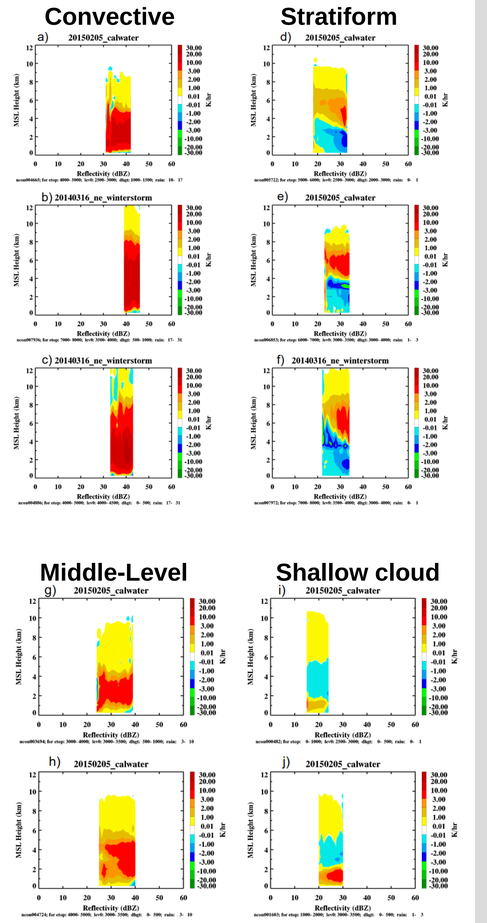



**Vertical profiles of latent heating/cooling (K h$^{-1}$)**
**Left panels:** Cross sections of original and retrieved LH
**Bottom panels:** Averaged for the cross-section and for the simulation domain

## Sample LH Profiles from the LUT




## Acknowledgements

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## Summary and Future works

NU-WRF is used to simulate six winter cases; the simulated precipitation properties (i.e., surface precipitation rates, composite radar reflectivity, freezing level height, and echo-top height) and their relationship with LH structures are examined and quantified. These precipitation properties can be obtained from the GPM DPR-GMI Combined algorithm to retrieve LH at higher latitudes. New "cold season" LUTs are built from the simulations using higher resolution property bins (vs V5). Also, the new LUTs include surface precipitation rate in the metrics, while vertical reflectivity gradient is eliminated (vs V5). A self-consistency check approach is used to examine the performance of the new LUTs. The Goddard CSH and Japan SLH teams are closely collaborating by sharing the same cases and comparing the LH structures. For example, (1) the SLH team just received all of GCE simulated cases, and (2) the CSH team will simulate a few cases over the Japan Sea, which are used for SLH's LUTs for winter systems. The CSH and SLH derived orbital LH will be compared and their similarities and differences identified. CSH is using two different LUTs, one for the Tropics and "warm season" (Lang and Tao 2018) and one for high latitude/winter events. Currently, the 2 sets of retrievals are transitioned from "warm" to "cold" using freezing level height (4 km -> 3 km).